

Systems Engineering Development Process Overview

Academy of Program Project and Engineering Leadership

APPEL Mission Statement

APPEL is the Agency focal point for enabling individual and team excellence in program/project management and engineering through the application of learning strategies, methods, models, and tools.

Introduction

NASA's strength and ability to carry out its new unifying Vision for Space Exploration increasingly depends on the development of its technical and program/project management workforce. The Systems Engineering Development Process (SEDP) is a roadmap to provide career training and development opportunities for agency program and project managers through a sequence of professional experiences, courses, and other strategies that support individual career goals and Center activities. The SEDP career development model outlines competencies (*see Appendix I for list of competencies*) at four levels of development relative to systems engineering roles.

The competency-based career development model is an integral part of the SEDP and serves as the mechanism to connect career planning and the requirements necessary to achieve the Agency's strategic thrusts. The SEDP grounds the training in the NASA culture. Another critical component is the Individual Development Plan (IDP), which serves as a self-assessment and planning tool and is completed by the employee (See Attachment I for Sample IDP). The SEDP supports one of NASA's strongest core values, which is its commitment to investing in and empowering the Agency's extraordinarily talented workforce to successfully execute programs and projects.

Objectives

The overall objective of the Systems Engineering Development Process (SEDP) is to provide a strategic and tactical approach for systems engineering development for individuals, Centers, and the Agency. Other objectives are to:

- Support employee training, retraining, professional development, and organizational development activities leading to better ways of delivering services, improving work performance, and increasing the value of employee contributions to current and future Agency missions.
- Support the full utilization of the NASA workforce in achieving NASA's strategic outcomes by: making training and development opportunities widely available; building and retaining a skilled and effective workforce; improving organizational performance; and maintaining scientific, professional, technical, and management proficiency.
- Highlight appropriate Agency and Center training courses that help develop specific competencies and proficiencies for designated roles.
- Use on-the-job training through selected work experiences as a primary method of developing job-related knowledge, skills, and abilities of employees.
- Promote an environment that supports continuous learning.

- Enhance employees' abilities to become accountable and responsible for their own learning and development.

Systems Engineering Development Process (SEDP): Practitioner's View

The SEDP career development process is one in which employees develop and implement individual development plans based on an assessment of themselves within the context of the organization. Successful career development involves a partnership between the employee, the manager, and the organization. In order for SEDP to be effective, employees will need the support and involvement of their managers and mentors, Center leadership, and others throughout the Agency (*See Appendix II for roles and responsibilities.*)

From the practitioner's perspective, there are five steps in the NASA career development process which are: 1) self-assessment; 2) exploring the NASA environment; 3) setting goals; 4) planning development strategies; and 5) executing. Figure 1 below illustrates the career planning steps in the SEDP.

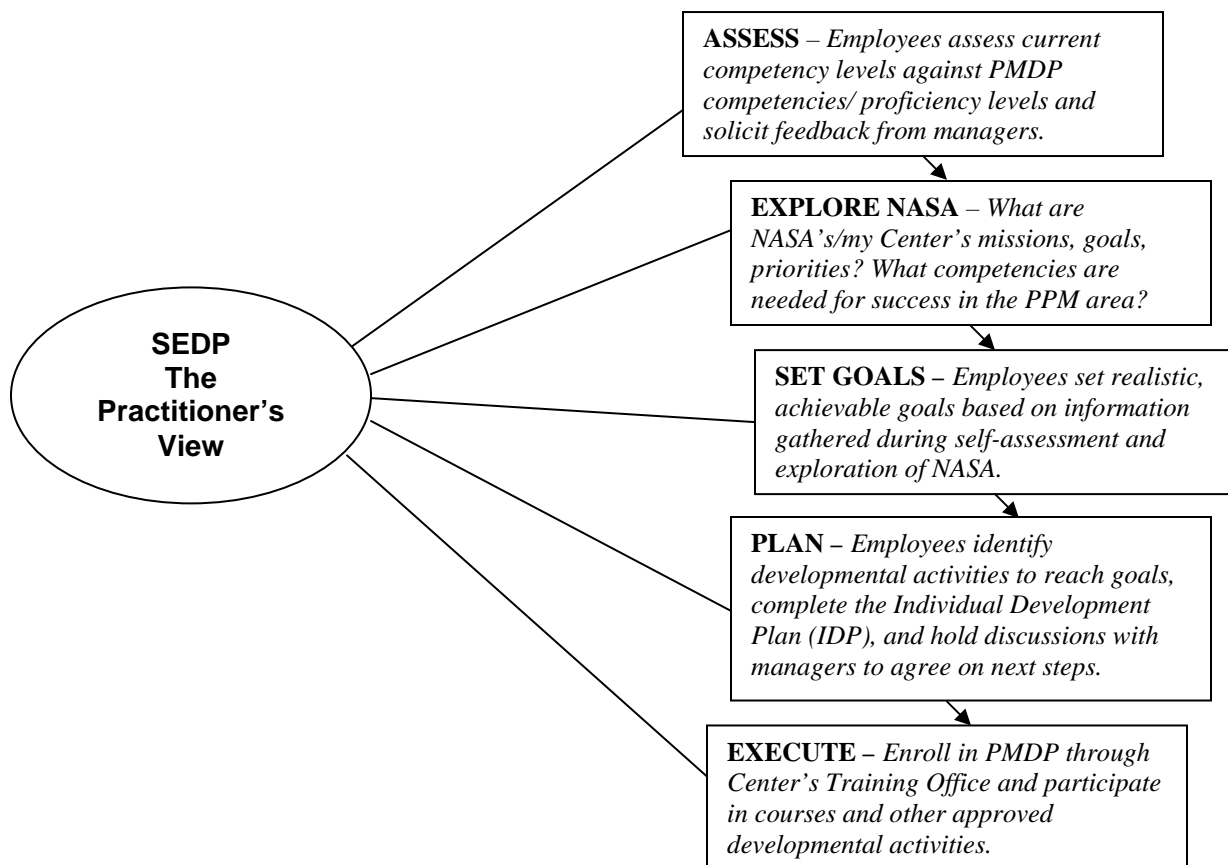


Figure 1. SEDP Career Development Model

Self-Assessment

The initial step in the self-assessment phase requires that employees assess their competencies and skills against those competency and proficiency levels identified for each of the four SEDP levels. This can be described as a competency gap analyses or the

identification of the gaps between the required or future competencies and their current competencies. It is important for each individual to first understand what he or she brings to the table and what he or she does best. To understand where a person's strengths are, an individual might begin by analyzing previous accomplishments and then assessing the competencies used to carry out the related activities. Revisiting previous performance evaluations may be a good source for identifying accomplishments and strengths. An important part of the self-assessment process is exploring how self-perceptions match those of others. Feedback will be obtained from immediate supervisors/managers, peers, mentors, and other appropriate people in the organization. Feedback from others can help the individual ensure that he or she is operating from a base of accurate and complete information.

Exploring the NASA Environment

Once employees have completed the self-assessment phase, the next step is exploring the Agency. It is important to understand NASA and the organizational realities that will affect individual career goals. To ensure effective planning, an employee might explore questions such as:

- What are NASA's (my Center's) mission, goals, priorities, and major challenges? Where is the organization headed? What are major systems engineering concerns now and in the future?
- What competencies does the Agency and my Center need to achieve success in the systems engineering area to achieve mission objectives? What competencies and proficiency levels do I need to gain knowledge in the various levels of systems engineering?
- What development activities are available within the organization that will help me reach my goals?

NASA has numerous resources to assist prospective project managers to explore the NASA environment such as:

- <http://www.education.nasa.gov/about/nasaent/index.html>
- The APPEL website (currently found at <http://www.appel.valador.com>)
- NASA Systems Engineering Processes and Requirements (NPR 7123)
- NASA Program and Project Management Processes and Requirements (NPR 7120.5c)
- Strategic Management and Governance Handbook

Additionally, talking with key NASA officials and mentors can provide very valuable information.

Setting Goals

Understanding both individual competencies and organizational needs has important implications for the career goals that each individual sets. The next task is to set realistic, achievable goals. A goal is more likely to be attainable if it is based on a match between

an individual's greatest strengths and the needs of the organization. The employees will set both short- and long-term goals that address their current situations and where they would like to go in the future. Because promotions and job changes are not guaranteed, employees usually identify several goals with various contingencies such as lateral movement or development of skills useful in the current job as well as future assignments.

Planning Development Strategies

The next steps in the SEDP are to plan development strategies and to complete the IDP (see Figure 2) in preparation for holding a discussion with an immediate supervisor or manager. The SEDP Model provides the framework within which it is possible to describe the appropriate job assignments, activities, education, coaching and mentoring, and training necessary to attain appropriate levels of capability. When planning strategies, employees should try to balance between formal classroom learning activities and other kinds of learning experiences.

Some helpful resources for identifying appropriate formal classroom learning activities include:

- Agency Master Course Schedule (<http://nasapeople.nasa.gov/training/master.pdf>)
- NASA's Systems Engineering Competencies: A Composite View (available upon request)
- APPEL Course Curriculum (Appendix III)
- APPEL Courses: Goals and Primary Foci (available upon request)

Examples of informal learning activities are:

- Estimate costs
- Allocate project level resources
- Develop project phase transition plans
- Create organizational breakdown structure

Examples of additional nontraditional learning experiences include:

- Interviewing subject matter experts or observing experts and mentors
- Researching and writing in an area of interest
- Creating opportunities to practice developmental competencies and skills
- Linking development goals to performance objectives
- Teaching in an area of interest

The employee and the manager should discuss proposed strategies and develop the final Individual Development Plan (IDP).

The IDP is designed to capture all of the information the employee has collected in summary form in preparation for the discussion with a supervisor or manager. Along with other documentation, the IDP allows employees to present their experience, training, and education in a consistent fashion across the Agency. It is a self-assessment and planning tool that serves as a road map for translating goals into action. The SEDP's IDP

emphasizes discussion and joint agreement between the employee and the supervisor involving future employee goals. The IDP is most effective when it is based on present and projected Agency needs; builds on current employee skills, competencies, interests, and career objectives; and represents the best possible integration of individual and organizational objectives. Each plan is uniquely tailored to the individual's and the Agency's needs. This supports the concept of "strategic staff development" which is the mutually beneficial process of linking individual aspirations and organizational needs.

Executing

The final step in the process is executing the plan. This means implementing the strategies by enrolling in the SEDP and participating in the courses and other development activities agreed upon during the employee/manager discussion. Level II through IV participants must be validated by the appropriate peer-group and center panel (*See SEDP Levels section later in this document.*) As the prospective project managers participate in the process, they should update the IDP portfolio on an ongoing basis. It is important to continuously update to document experiences and evidences of competency achievements.

If you have questions regarding this document, please contact Gary Yale at yale1963@adelphia.net.

Figure 2. Sample Individual Development Plan

EMPLOYEE INFORMATION	
<i>Employee Name:</i> John Moon	<i>Date:</i> October 11, 2005
<i>Current Position:</i> Systems Engineer	<i>Center:</i> Goddard Space Flight Center (GSFC)
<i>Length of time in present position:</i> 3 years	<i>Length of time at NASA:</i> 5 years
<i>Summary of Prior Work Experience:</i> Assisted in the design of electrical sub-systems. Worked with staff at Lockheed-Martin to design and test sub-systems. Coordinated preparation of systems level testing.	
<i>Educational Background/Certifications:</i> B.S. Electrical Engineering	
<i>Training Taken in Last Year:</i> Acquisition Management, Team Leadership, Project Planning	
SELF-ASSESSMENT	
<i>Summary of skills and competencies:</i> <ul style="list-style-type: none"> - Exposure to NASA's project management tools and techniques. - Functional expert for spacecraft electrical power conditioning systems - Two years of experience as a sub-systems lead for electrical systems - Good analytical and problem-solving skills (prevented three-month schedule slip by proving test anomaly resulted from use of improper database rather than an actual hardware anomaly) - Excellent understanding of GSFC strategic mission 	
SHORT- AND LONG-TERM GOALS	
<i>Development/Career Goals:</i> <ul style="list-style-type: none"> - Become a project manager for a medium to small project - Better understand the process of defining requirements, concepts, and project plans - Gain additional experience as sub-systems lead for systems outside of electrical systems - Obtain an advanced degree in engineering management 	
DEVELOPMENT NEEDS	
<i>Areas that need to be developed in relation to goals (skills/competencies, completion of degree, exposure to other areas of the Agency, etc.):</i> <ul style="list-style-type: none"> - Ability to lead high performance work teams - Exposure to other sub-systems design and development - Interpersonal skills (comfort level and effectiveness in dealing with different people and groups) - Enhance capabilities to define requirements, concepts, and project plans 	

Figure 2. Sample Individual Development Plan (cont'd.)

ACTION PLAN TO ADDRESS DEVELOPMENT NEEDS		
<i>Consider what type of action would best meet your identified development goals and needs. Specify strategies and resources to implement the plan.</i> <i>Development strategies (special assignments, formal training, job rotations, etc.)</i>		
Strategy:	Resources Needed:	Timeline:
ILDP courses – FOU120-Lifecycle, Processes & Systems Engineering Mgmt. FOU150 – Project Planning Analysis & Control	Approval of manager and course registration	When available
Rotate to another sub-system on current project	Work with manager to identify appropriate rotation	FY-2006
Shadow project team leader and assume greater level of responsibilities	Discuss available opportunities to practice skills with project team lead	May 2006
Enroll in George Washington University's Master's of Engineering Program	Course registration and funded tuition reimbursement	September 2006
Take a course in Interpersonal Skills and solicit feedback from peers	Course registration and support from peers	TBD
<i>Immediate next steps agreed to by employee and manager:</i> 		
<i>Timeframe for progress review:</i> 		
<i>Employee's signature:</i>		<i>Date:</i>
<i>Manager's comments:</i> 		
<i>Manager's signature:</i>		<i>Date:</i>
<i>Progress review/update notes:</i> 		

Systems Engineering Development Process (SEDP) Levels

The SEDP career development model consists of four career levels reflecting increased responsibilities and performance expectations. These levels are specific to systems engineering roles. To support the SEDP process, systems engineering competencies and proficiency levels have been defined for each level. As highlighted in Figure 3. The Rock (Required Occupational Capabilities and Knowledge), APPEL provides a variety of learning activities to support each career level.

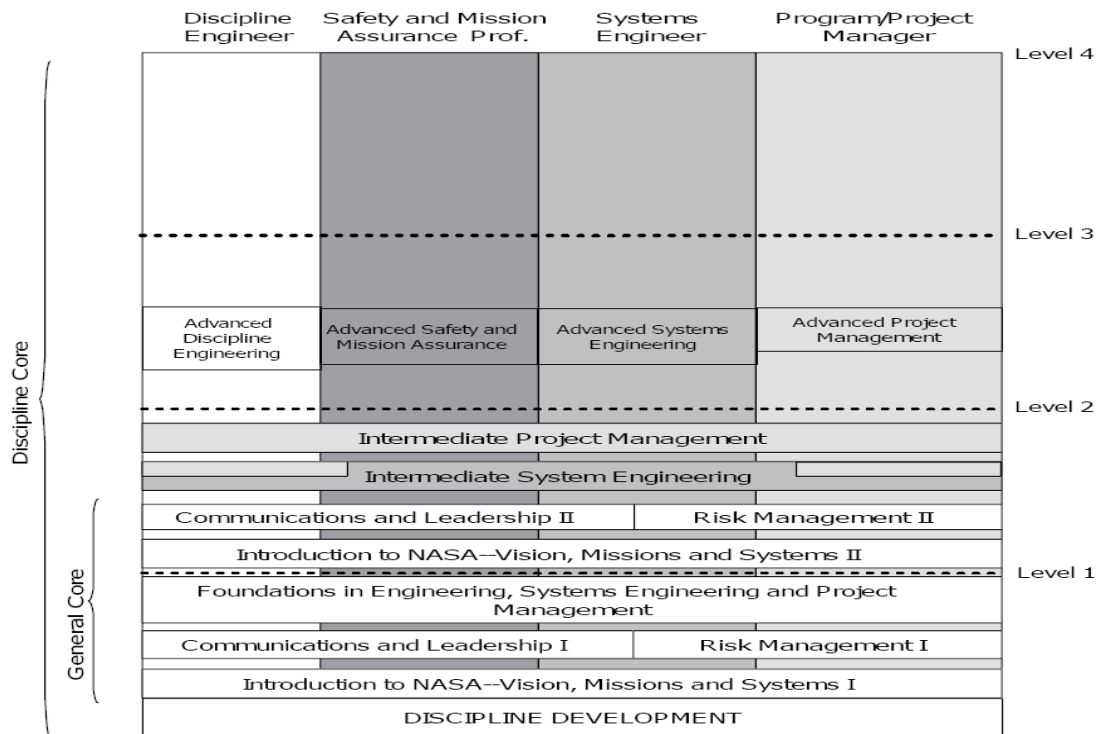


Figure 3. The ROCK—Required Occupational Capabilities and Knowledge.

- At Level 1, the project team member performs fundamental and routine activities while supporting a Level II-IV system engineer or project manager as a member of a team -- often a functional expert, business manager, systems engineer, scientist, or project control agent. *Level I portfolios are validated by a practitioner's immediate supervisor or manager.*
- To reach Level 2, the individual performs systems engineering activities for a small project or subsystem to a larger effort (e.g. no more than one or two simple internal/external interfaces, simpler contracting processes, smaller team/budget, shorter duration). *Level 2 portfolios are validated by the Center Peer Group and SEDP panel.*
- To reach Level 3, the individual performs as a systems engineer of a more complex project (multiple distinct subsystems, or other defined services, capabilities, or products) with associated interfaces. *Level 3 portfolios are validated by the Center Peer Group and SEDP panel.*
- Participants who reach Level 4 perform as systems engineers of very large, complex projects with multiple internal/ external interfaces. *Systems Engineers' SEDP portfolios are validated by the Center Peer Group, SEDP Panel and an agency-wide panel.*

The SEDP and the competency model are both focused on identifying those measurable and developable competencies that predict high performance for project practitioners. The planned curriculum includes courses designed to develop competencies. Practitioners are expected to complete these courses or other equivalent activities.

Conclusion

Systems Engineering Development Process (SEDP) adds value when it helps individuals and the organization do better than their present level of performance. The process helps individuals learn how to adjust to NASA's culture and to become and remain productive under changing conditions. The emphasis on individual development and the willingness to provide resources demonstrates NASA's willingness to foster both professional and personal growth for its employees. Focusing on employee growth and development and creating realistic development plans will be a growing influence in NASA's abilities as it transforms itself. The purpose of SEDP is to enhance current performance and enable individuals to take advantage of future opportunities. The SEDP does not automatically result in promotions or increases in pay. There are no guarantees, except that anyone participating in the process will be better prepared to accomplish the mission, and will be recognized as a true professional in NASA and beyond. APPEL's vision is one in which every member of NASA's technical and program/project management workforce has an active IDP that can lead each to his or her full potential.

Appendix I: Systems Engineering Competencies

1.0 Concepts and Architecture

- 1.1 Mission Needs Statement
- 1.2 System Environments
- 1.3 Trade Studies
- 1.4 System Architecture

2.0 System Design

- 2.1 Stakeholder Expectation Definition & Management
- 2.2 Technical Requirements Definition
- 2.3 Logical Decomposition
- 2.4 Design Solution Definition

3.0 Production, Product Transition, Operations

- 3.1 Product Implementation
- 3.2 Product Integration
- 3.3 Product Verification
- 3.4 Product Validation
- 3.5 Product Transition
- 3.6 Operations

4.0 Technical Management

- 4.1 Technical Planning
- 4.2 Requirements Management
- 4.3 Interface Management
- 4.4 Technical Risk Management
- 4.5 Configuration Management
- 4.6 Technical Data Management
- 4.7 Technical Assessment
- 4.8 Technical Decision Analysis

5.0 Project Management and Control

- 5.1 Acquisition Strategies and Procurement
- 5.2 Resource Management
- 5.3 Contract Management
- 5.4 Systems Engineering Management

6.0 NASA Internal and External Environment

- 6.1 Agency Structure, Mission, and Internal Goals
- 6.2 NASA PM/SE Procedures and Guidelines
- 6.3 External Relationships

7.0 Human capital Management

- 7.1 Technical Staffing and Performance
- 7.2 Team Dynamics and Management

8.0 Security, Safety & Mission Assurance

- 8.1 Security
- 8.2 Safety and Mission Assurance

9.0 Professional and Leadership Development

- 9.1 Mentoring & Coaching
- 9.2 Communication
- 9.3 Leadership

10.0 Knowledge Management

10.1 Knowledge Capture and Transfer

Appendix II: Roles and Responsibilities

Individuals

Although the Agency and Centers are responsible for clarifying competencies essential for mission success, the employees will take the lead role in the development process supported by their managers and the Centers. Prospective systems engineers will:

- Envision what they want their careers to look like today and in the future, taking into account NASA's vision, missions, and mission directorates.
- Assess their aptitudes, strengths, and development needs with their managers/mentors using tools such as SEDP competency worksheets and the IDP.
- Prepare an individual portfolio that supports both the current job and longer-term professional goals within the systems engineering work environment. The portfolio will contain a current IDP, performance evaluations, awards, and success stories from past and current projects.
- Work with their managers to schedule appropriate on-the-job learning, required complementary formal training, and developmental activities to address developmental gaps.
- When possible, identify a mentor to support their career planning activities.

Managers

The immediate manager:

- Discusses the goals and plans with the employee, offering candid feedback, provides advice or information on available resources and opportunities
- Mentors and coaches employees or assists the employees in finding suitable mentors for their development planning
- Creates and supports on-the-job experiences to enhance development (i.e. shadowing assignments, Source Evaluation Board participation, project reviews, HQs rotations, etc.)
- Helps the employee define short-term and long-term development and training in line with the Center's strategic plan and individual career goals
- Reviews and discusses the IDP, and development portfolios with the employee
- Approves placement of employees at Level I of SEDP and forward documentation to a Center SEDP Point of Contact (POC) for maintenance
- Reviews and forwards employee documentation to the Center SEDP POC for placement at Levels II, III and IV of SEDP

Centers

The Center provides the tools, resources, and the structure to support the SEDP at their locations. Center leadership:

- Sets priorities for the development of personnel in their Centers
- Identifies the competencies and proficiency levels needed for the systems engineering community to carry out present and envisioned systems engineering roles

- Provides a wide variety of learning and development opportunities for practitioners ranging from Center-sponsored training courses to targeted development programs
- Coordinates with the NASA Academy for Program/Project and Engineering Leadership in the Office of the Chief Engineer
- Establishes SEDP Review Boards who will: 1) review and recommend candidates for SEDP Levels, II, III, and IV; and 2) forward recommendations to the center director for approval
- Designates the Center NASA APPEL SEDP POC who:
 - Maintains all SEDP-related documentation
 - Encourages and supports the inclusion of SEDP in the recruitment and selection process for systems engineers at the Center.
 - Supports Center managers in creating developmental assignments in Center-wide programs and projects for APPEL SEDP participants
 - Provides coaching and mentoring to Center supervisors and participants on the SEDP process and materials as needed

The Academy of Program Project and Engineering Leadership (APPEL)

APPEL (in the Office of the Chief Engineer):

- Identifies and prioritizes systems engineering competencies throughout the Agency
- Provides a curriculum for Agency-sponsored programs linked to the career development model supporting the development of commonly required competencies

The Agency

The Agency works and supports Center activities by:

- Ensuring that an organizational structure exists to support the required knowledge, skills/competencies, and experiences necessary for the development of its employees
- Providing resources-- dollars and time -- for development to occur
- Providing a clear road map for career development activities
- Identifying and using the talents, abilities and resources of each employee in support of organizational goals
- Developing a proactive and realistic approach to meeting future staffing needs

Appendix III: The Academy of Program Project and Engineering Leadership (APPEL)

COURSE CURRICULUM

The APPEL technical professional development model identifies General Core and Discipline Core Curriculum. The General Core suggests activities and courses that should be taken by all employees during their technical professional development, whereas, the Discipline Core identifies courses and activities associated with specific disciplines like Program/Project Management, System Engineering, Safety and Mission Assurance and the Engineering Disciplines. Others, for example, professionals performing procurement or acquisition activities, should benefit from this model, as well.

General Core

The General Core is organized as shown in Levels 1 and 2 of the diagram above for ease of understanding and application. The General Core provides focus areas for professional development appropriate for all disciplines including:

Introduction to NASA—Vision, Missions and Systems (VMS)
Communications and Leadership (CL)
Risk Management (RM)
Foundations in Engineering, System Engineering and Project Management (FOU)

Embedded in the APPEL model is the fact that the people performing in specific disciplines form the basis for most activities at NASA, so much of the early development of NASA's employees takes place within the specific technical and non-technical disciplines. This early and continued development, enhancing understanding and capability, is usually managed by the employee with support from his or her supervisor and possibly Center leadership.

Discipline Core

The Discipline Core is aimed at developing and enhancing skills in a specific discipline. For example in Level 2, the system engineering and project management discipline core is described.

The Academy of Program Project and Engineering Leadership recommends the following learning activities shown in Levels 1 and 2 as significant opportunities to help NASA's professionals enter the workforce, enhance their capabilities and support career development efforts at NASA. The table identifies General Core (appropriate for all technical disciplines) and Discipline Core (system engineering (SE) and project management (PM)).

Electives—electives include specialty courses and may include technical symposia, productivity training, and any other courses deemed appropriate by an employee and their supervisors.

Table 1. Course Listing

Level	Designation	Title	Core
1	VMS 100	Introduction to Aerospace at NASA (updated IAN)	Gen
	FOU 100	Requirements Development and Management (updated REQ)	Gen
	FOU 120	Lifecycle, Processes and System Engineering Management (new SM)	Gen
	FOU 150	Project Planning Analysis and Control (PPAC)	Gen
	FOU 160	NASA's Budgeting Process (new)	Gen
	CL 100	Technical Writing for the NASA Engineer (new)	Gen
	CL 150	Team Membership (new)	Gen
	RM 100	Foundations of Risk Management (updated)	Gen
2	<i>Select two VMS Course Modules</i>		
	VMS 200	Science Missions and Systems: Design and Operations (SMSDO)	Gen
	VMS 210	Exploration Systems and Human Space Operations (updated EXPO)	Gen
	VMS 220	Space Launch and Transportation Systems: Des and Ops (SLTS)	Gen
	VMS 230	Introduction to Aeronautics (mission directorate course)	Gen
	VMS 240	Science Mission and Systems: Design and Operations LAB (updated)	Gen
	VMS 250	Mars Mission and System Design LABORATORY (updated)	Gen
	CL 200	Communicating Technical Issues (new)	Gen
	CL 250	Team Leadership (new)	Gen
	CL 260	Negotiation (revised)	Gen
	RM 200	Continuous Risk Management (updated)	Gen
	ISE 200	Concept Exploration-System Engineering Fundamentals (SEF-1)	SE/PM
	ISE 210	Developing/Implementing System Engineering Management Plans (new)	SE
	ISE 220	System Validation and Verification (updated SVV)	SE/PM
	ISE 230	Transition, Product Delivery and Mission Operations (new)	SE/PM
	ISE 240	Decision Analysis (new)	SE/PM
	IPM 200	Schedule and Cost Control (new)	PM
	IPM 210	Performance Analysis Workshop (new)	PM
	IPM 220	Acquisitions and Contracting at NASA (new)	PM
	IPM 290	Project Management Leadership LAB (revised)	PM
E L E C T I V E S	IDEA	Innovative Design for Engineering Applications	Any
	SAGE	Selected Axioms of Good Engineering	Any
	IRP	Introduction to Rapid Prototyping	Any
	PBSOW	Performance-Based Statement of Work	Any

Table 1. Course Modules for Levels 1 and 2. *All Level 1 course modules are appropriate for all technical disciplines and required for system engineers and project managers. The VMS, CL and RM course modules in Level 2 are appropriate for all technical disciplines. All Level 2 course modules, except the IPM series, are required for system engineers. All Level 2 course modules are required for project managers, except IPM 210.*